Investigation of the distribution of ^{137}Cs in the surface layer of the Southern Ocean (Atlantic sector)

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Abstract. The study of latitudinal distribution of ^{137}Cs concentrations at 19 stations in the surface water of the Southern Ocean on sections to the South from Cape of Good Hope (section SR2) and in Drake Passage (30th cruise "Academic Ioffe", 01.12.2009 – 09.01.2010) were performed. The data received reveal the exponential decrease of the ^{137}Cs concentrations in the surface water of the Atlantic sector of the Southern Ocean. Increased ^{137}Cs concentrations were registered in the Drake Passage and at the section SR2 in vicinity of the Polar Front It is notable that the highest concentration was found in the point with the local minimum salinity. Increased ^{137}Cs concentrations in the surface water may be explained by the ^{137}Cs additional input by melt water from adjacent continental glaciers.

1. INTRODUCTION

Spatial and temporal variations of ^{137}Cs concentrations in the surface waters of the global ocean for the period from 1957 to 2005 were investigated in the article Y. Inomata [2]. It was shown that according to these data in the Atlantic sector of the South Ocean, the ^{137}Cs concentrations decreased exponentially after 1961 from the highest concentration (5.4 ± 0.4 Bq m^{-3}) in 1961 to (0.8 ± 0.3 Bq m^{-3}) in 1990s. Later, in 2002, ^{137}Cs concentration (0.7 ± 0.2 Bq m^{-3}) in this region was similar to that measured in 1990s. It was supposed that at 50-60 S and near the Antarctic coast an additional input of ^{137}Cs to these waters takes place [1].

It was supposed also that the increased ^{137}Cs concentrations may be connected with an additional input of ^{137}Cs with melt water from adjacent continental glaciers. In our study we tried to receive additional data in the Drake Passage and in the other regions of the Southern Atlantic ocean to confirm this assumption.

2. MATERIALS AND METHODS

The hydrological structure of the Southern Ocean is determined by the Antarctic Circumpolar Current (ACC). From north to south, the frontal jets of the Antarctic Circumpolar Current bordered the Southern Atlantic Ocean into zones with specific hydrological, hydrophysical and hydrochemical structure. Such different hydrological conditions with various intensity of vertical and horizontal mixing suggest the different half-life ^{137}Cs . It obviously must be efflect on spatial latitudinal distribution of ^{137}Cs concentrations in the surface water of this region.

In our study the latitudinal distribution of concentrations ^{137}Cs at 19 stations in the surface water of the Southern ocean on sections to the south from Cape of Good Hope (section SR2) and in Drake passage (30th cruise "Academic Ioffe", 01.12.2009 – 09.01.2010) were performed (Fig. 1). Sections crossed the main

frontal systems in the Southern Ocean which were identified as the Subantarctic Front (SAF), the Polar Front (PF), the Southern ACC Front (SACCF), and the southern boundary of the ACC [4].

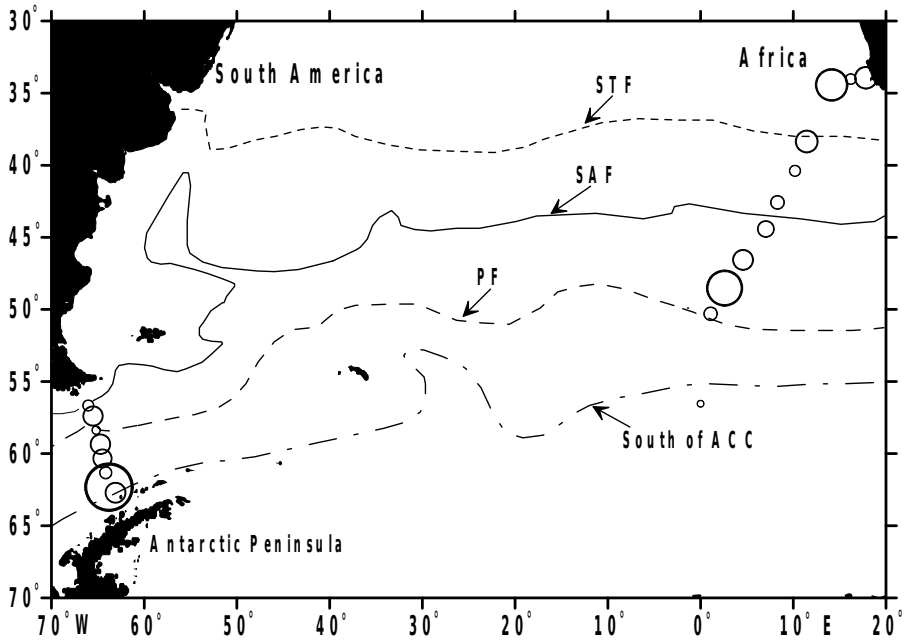

Fig. 1. The main frontal systems in the Southern Ocean [4] and position of the sampling sites.

The samples of water (100L) from the surface were taken with a bucket. For radiochemical ^{137}Cs concentration from the samples of sea water, a consecutive filtration of the water (100L) through 2 capsules filled with a selective sorbent on ^{137}Cs (cobalt ferrocyanide) was used (the technique developed by Livingston [3]. The activity of ^{137}Cs on adsorbers was measured by gamma Spectrometry using a high-purity germanium detector GC-3020 with a relative efficiency of 30% (Co-60 line - 1.332 Mev) and a resolution of 1.8 Kev.
The efficiency of sorption of the dissolved ^{137}Cs was calculated by comparison of activities on the first and second serial ferrocyanide absorbers.

3. RESULTS AND DISCUSSION

The surface concentrations of ^{137}Cs measured in the water along the sections presented in
Tables 1 and 2.

Table 1. List of stations and description of water samples collected on section SR2.

N	Data	Station	Coordinates		Depth (m)	Temperature °C	Salinity ‰	Concentration ^{137}Cs Bq m^{-3}
			Latitude	Longitude				
1	01.12.2009	2158	33°56.22	17°49.68	246	14.50	35.04	0.21 ± 0,05
2	02.12.20	2201	34°01.6	16°12.06	3586	18.60	35.6	0.09 ± 0,03

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3	04.12.2009	2207	34 °25.98	14°08.16	4588	19.22	35.617	0.32 ± 0,08
4	07.12.2009	2220	38 °21.42	11 °27	5115	16.49	35.417	0.21 ± 0.06
5	09.12.2009	2227	40 °23.4	10°10.74	4538	16.17	35.299	0.10 ± 0.04
6	11.12.2009	2236	42 °34.8	8 °17.64	3920	11.06	34.372	0.12 ± 0.04
7	12.12.2009	2241	44 °25.38	7 °02.28	4566	8.42	33.918	0.15 ± 0.05
8	14.12.2009	2249	46 °33.96	4 °34.8	4179	7.22	33.814	0.20 ± 0.06
9	16.12.2009	2256	48 °31.2	2 °35.46	4006	5.75	33.759	0.36 ± 0.06
10	18.12.2009	2262	50 °2.98	1 °08.4	3035	5.27	33.794	0.12 ± 0.07
11	22.12.2009	2282	56 °32.34	0 °	3729	0.07	34.159	0.06 ± 0.03

Table 2. List of stations and description of water samples collected on section in the Drake Passage

N	Data	Station	Coordinates		Depth (m)	Temperature ˚C	Salinity ‰	Concentration ^{137}Cs Bq m^{-3}
			Latitude	Longitude				
1	02.01.2010	2287	62°42.67	63°05.52	1988	0.58	33.787	0.03 ± 0.01
2	03.01.2010	2293	62°19.48	63°47.67	4195	0.53	33.714	0.50 ± 0.13
3	04.01.2010	2299	61°19.36	64°09.04	3516	0.94	33.748	0.10 ± 0.04
4	05.01.2010	2301	60°20.08	64°30.03	3225	1.79	33.770	0.18 ± 0.05
5	06.01.2010	2311	59°20.75	64°43.03	3559	2.42	33.652	0.19 ± 0.11
6	07.01.2010	2317	58°22.59	65°10.91	3630	3.38	33.776	0.06 ± 0.02
7	08.01.2010	2323	57°23.49	65°31.25	4247	3.73	33.845	0.19 ± 0.04
8	09.01.2010	2328	56°39.76	66°01.87	3945	6.56	33.991	0.09 ± 0.03

The latitudinal distribution of concentrations ^{137}Cs on section SR2 and in the Drake Passage presented on fig. 2 and 3.

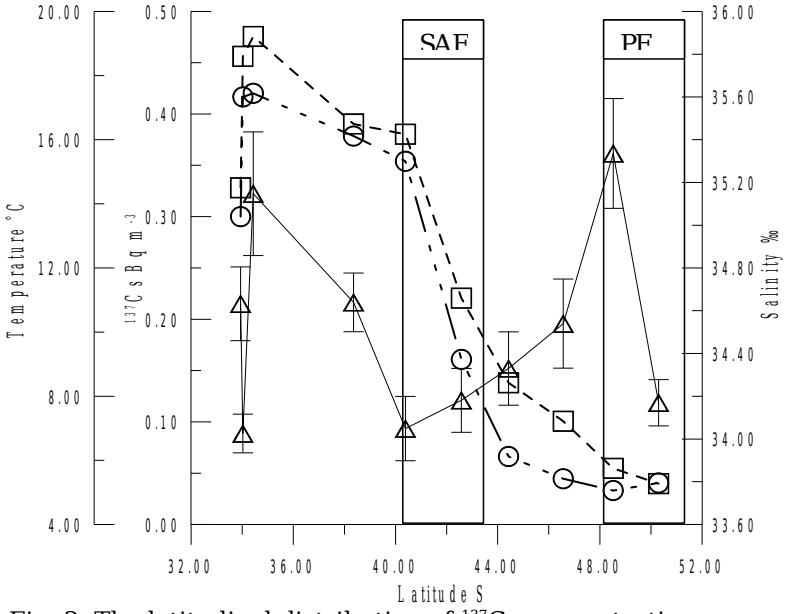

Fig. 2. The latitudinal distribution of ^{137}Cs concentrations on section SR2
Δ - ^{137}Cs concentrations, □ – temperature, ○ - salinity.

The average value of ^{137}Cs concentrations for cross-section SR2 reached 0.18 Bq m^{-3} σ = 0.10.

The increased ^{137}Cs concentration (0.32±18% Bq m^{-3}) was registered in the northern part of the section SR2. This feature probably is determined by an input of surface water from the Indian Ocean with the Agulias current. The ^{137}Cs concentrations decrease with increasing of latitude in direction to Subantarctic Front. After crossing the Subantarctic Front, the ^{137}Cs concentrations increased up to 0.36 ± 0.06 Bq m^{-3} at the Northern boundary of the Polar Front. Further, in a zone of Polar Front ^{137}Cs concentrations decreased. It is notable that the highest concentration was found in the point with the local minimum salinity of 33.759 ‰.

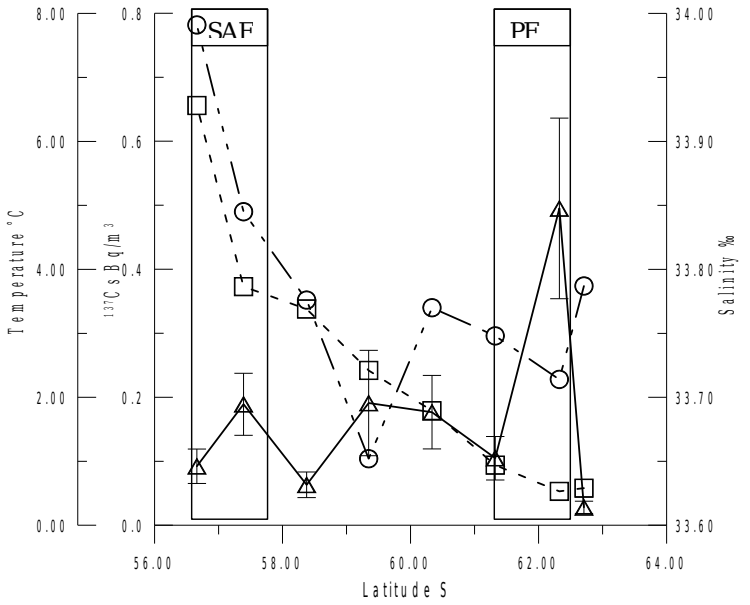

Fig. 3. The latitudinal distribution of ^{137}Cs concentrations on section in the Drake Passage
Δ - ^{137}Cs concentrations, □ – temperature, ○ - salinity.

The section in the Drake Passage crosses the zone of Polar Front and Subantarctic Front. The average value of concentration of ^{137}Cs in the surface water in the Drake Passage equal 0.19 Bq m^{-3} σ = 0.13.
The highest concentration of ^{137}Cs (0.50 ± 0.13 Bq m^{-3}) was noted in the southern part of the section, at the southern boundary of the Polar Front. It is the zone of mixing Subantarctic and Antarctic waters. This maximum of ^{137}Cs concentration was also found in the point of a local minimum of salinity (33.714 ‰). Received maximal concentration of ^{137}Cs is comparable to results of measurements in Drake Passage in 2002 year (0.57 ± 0.15 Bq m^{-3}) [1]. In Antarctic coastal water, concentration of ^{137}Cs was 0.34 ± 0.12 Bq m^{-3} [1].

The average value of ^{137}Cs concentrations for all measurements reached 0,18 Bq m^{-3} σ = 0,11. This value of concentration is significantly lower than the values 0.8 ± 0.3 Bq m^{-3} in 1990s and in 2002 year - 0.7 ± 0.2 Bq m^{-3} for the box of the Southern part of Atlantic Ocean (Box 30, SAO) [2]. Comparison with the data for Antarctic Ocean (Box 13) shows that the graphical interpolation to 2010 year points to values ~ 0,2 Bq m^{-3} which agrees with our average value (Fig. 4). So the received data confirm the exponential decreasing the ^{137}Cs concentrations in the surface water of the Antarctic Ocean.

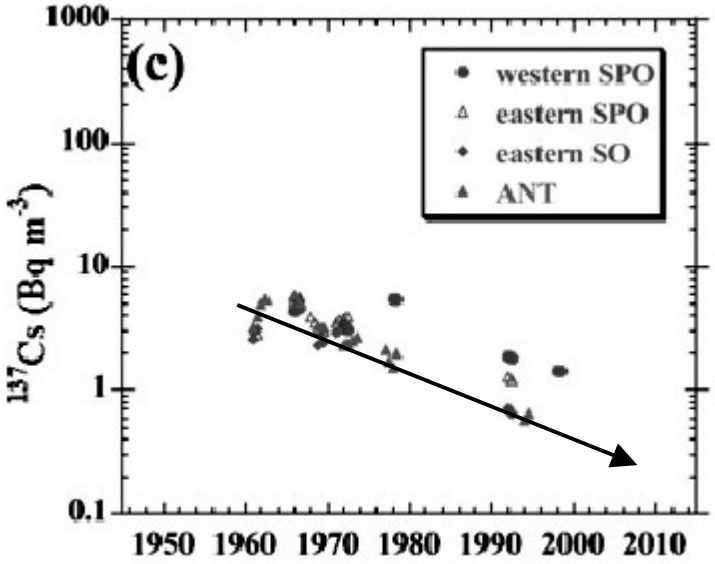

Fig. 4. The half-year averaged values for ^{137}Cs concentration in surface seawater of the Antarctic Ocean and the South Pacific Ocean (boxes 10-13) [2]. The picture and the data were taken from [2]. The line was drawn through the data for Antarctic Ocean.

Thus, the comparison of the measured concentrations of ^{137}Cs in a surface water of the Southern Ocean south of the Cape of Good Hope (section SR2) and in the Drake Passage with the data of paper [1] do not reveal stationary level ^{137}Cs concentrations in the Southern Ocean during the period 1990s to 2002y. It is not enough measurements to justify such phenomenon.

4. CONCLUSION

The data received reveal the exponential decrease of the ^{137}Cs concentrations in the surface water of the Atlantic sector of the Southern Ocean.
Increased ^{137}Cs concentrations in the Drake Passage and in the coastal Antarctic water may be explained by ^{137}Cs additional input by melt water from adjacent continental glaciers as supposed by [Gulin et al., 2005] In our study we also found increased ^{137}Cs concentrations in the Drake passage and at the section SR-2 in vicinity of the Polar Front. Increased ^{137}Cs concentrations were found in the points of a local minimum of salinity

References

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